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SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

Point de l'ordre du jour : D.3.1

France

QUELQUES APPLICATIONS DE LA TECHNIQUE ET DE LA MISE EN OEUVRE DES EQUIPEMENTS ELECTRIQUES A HAUTE TENSION DANS LES PAYS EN VOIE DE DEVELOPPEMENT

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QUELQUES APPLICATIONS DE LA TECHNIQUE ET DE LA MISE EN OEUVRE DES EQUIPEMENTS ELECTRIQUES A HAUTE TENSION DANS LES PAYS EN VOIE DE DEVELOPPEMENT.

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1) INTRODUCTION.-

Les équipements des réseaux électriques à Haute Tension (H.T.) constituent, en quelque sorte, les systèmes sanguins des pays jeunes .

Après un bref rappel de la nature et du rôle de ces équipements, nous examinerons quelles sont les incidences que peuvent avoir les conditions particulières locales sur leur conception technique et sur leur mise en oeuvre .

2) NATURE ET ROLE DES EQUIPEMENTS H.T.-

Situés entre le producteur et le consommateur, les équipements H.T. ont pour rôle essentiel de transporter à distance l'énergie électrique par l'intermédiaire de postes de transformation ou d'interconnexion et de lignes électriques dont les tensions en courant alternatif s'échelonnent aujourd'hui de 15 kV à plus de 500 kV .

Les postes de coupure et de transformation , constituent les noeuds vitaux des réseaux de transport . Ils ont pour rôle :

- de transformer la tension de l'énergie, en vue d'en réduire le coût du transport ;
- de contrôler ce transport et d'en régler la tension ;
- de protéger le réseau complet contre les surcharges et contre les défauts .

Types d'appareils :

Pour remplir ce rôle, les principaux types d'appareils, sont :

- Les Transformateurs de puissance qui ont pour but d'élever ou d'abaisser la tension et également de la régler en partie .
- Les Disjoncteurs qui ont pour mission de couper en charge les artères sous l'action volontaire d'une commande à distance ou sous l'action automatique d'une protection . Ces appareils peuvent être de différents types : à gros volume d'huile, à petit volume d'huile ou à air comprimé .
- Les Sectionneurs qui ont pour fonction d'isoler certains tronçons .
- Les Transformateurs de Mesure , de Courant et de Tension .
- Les Parafoudres protègent le matériel contre les surtensions .
- Les Equipements Basse Tension associés aux équipements H.T. comprenant notamment les pupitres et tableaux de commande, de contrôle et de protection .

3) INCIDENCE DES CONDITIONS LOCALES SUR LA CONCEPTION TECHNIQUE DES EQUIPEMENTS H.T. -

a) Conditions géographiques et climatiques .-

Le retard dans le développement économique et industriel d'une région est fréquemment la conséquence, au moins partielle, de conditions géographiques et climatiques particulièrement dures . L'examen de ces facteurs, souvent nouveaux pour la technique, prend donc sa place dans cette étude .

- La température due à l'ensoleillement a conduit certains constructeurs à prévoir des bâtiments entiers ou des auvents spéciaux pour protéger l'appareillage et les transformateurs, ou bien à utiliser de véritables enveloppes isothermiques quand l'emploi de peinture argentée était insuffisant .

La câblerie de liaison doit être enterrée à profondeur suffisante pour éviter les élévations de température journalière au voisinage de la surface du sol, et les remontées extérieures de câbles doivent être faites de préférence sur les parois non ensoleillées aux heures chaudes .

- Les vents, tornades et cyclônes qui menacent, en permanence certaines régions tropicales nécessitent le renforcement des pylônes .

- Les orages fréquents et violents dans ces mêmes régions ont entrainé des exigences beaucoup plus poussées en matière d'isolement des transformateurs et de caractéristiques des parafoudres .

- Les tremblements de terre répétés justifient l'utilisation de montages souples, ou de dispositif de fixation au sol des transformateurs .

- La nature du sol peut avoir des caractéristiques de dureté très variable suivant les saisons . Ceci est important , par exemple, pour la détermination des massifs de pylônes de ligne . Un sol parfaitement résistant à la pioche, en saison sèche , peut devenir complètement inconsistant à la saison des pluies et il est prudent, lorsqu'on fait une étude d'un tel sol, de noyer le terrain jusqu'à complète saturation pour en faire l'essai .

- Les poussières sont très nocives dans les régions désertiques où elles sont silicieuses et rarement lavées par la pluie. Un remède consiste à rendre complètement étanches tous les mécanismes des appareils par utilisation de joints en matière plastique ; on peut être amené également à carèner certains appareils contre les effets abrasifs des vents de sable , ou encore à installer le poste complet dans un bâtiment spécial avec ventilation d'air à travers des filtres à poussière . A l'extérieur, il est utile parfois de renforcer l'isolement ou de prévoir double artère ou double jeu de barres omnibus afin de pouvoir procéder au nettoyage d'une partie de l'installation, l'autre restant en service .

- L'humidité se rencontre, surtout, dans les régions tropicales et équatoriales ou au voisinage de la mer où elle est aggravée par la salinité de l'air . Nous n'insisterons pas sur ce très vaste sujet qui, avec celui des insectes, de la vermine et des moisissures englobe l'ensemble des problèmes de la " tropicalisation " du matériel. Ces problèmes font depuis de nombreuses années, l'objet de recherches d'études et de rencontres entre constructeurs . Leur examen sortirait du cadre de ce rapport .

- La faune qui vit dans certaines régions sauvages mérite, par contre, d'être évoquée en raison du caractère particulier des déprédations qu'elle provoque plus spécialement sur les lignes aériennes moins surveillées que ne le sont les postes de transformation. C'est le cas des éléphants qui se frottent aux pylônes . On peut remédier à cela, soit en creusant un large fossé autour des pylônes, soit plus économiquement en renforçant le fil de garde monté en tête des pylônes de façon à réaliser comme un haubanage horizontal énergique qui maintiendra en place le pylône même déformé dans sa partie inférieure .

  De même, pour empêcher les singes et les serpents d'accéder aux consoles des pylônes on peut placer à la partie inférieure de l'appui, des tôles inclinées vers le sol.

- Citons encore les feux de brousse dans les zônes de savane . Ils peuvent amener la destruction des poteaux en bois, l'éclatement des isolateurs et même la détérioration des pylônes métalliques . Il importe donc de veiller, beaucoup plus que dans les régions tempérées, sur le maintien des layonnages .

b) Degré d'évolution des réseaux .-

Les caractéristiques principales d'un réseau jeune, sont les suivantes :

- simplicité du schéma : les centrales peu nombreuses, distribution radiale,
- puissances transportées relativement faibles ,
- étendue du réseau vaste en regard de sa puissance .

Sur le plan technique, ceci conduit à :

- L'utilisation de tensions assez élevées pour les puissances transportées .
- Donc, l'utilisation de transformateurs de faibles puissances par rapport aux tensions. Ces appareils présentent la particularité d'avoir des bornes H.T.démesurées .
- L'utilisation de disjoncteurs de tensions élevées à pouvoir de coupure réduit . Exemple: disjoncteurs à 100 kV de 500 MVA seulement soit 5 fois plus faibles environ que ceux habituellement fournis pour la même tension .
- l'adoption de protections simplifiées puisque souvent l'énergie ne s'écoule que dans un seul sens, et permet de se dispenser de protection directionnelle, voire de supprimer le disjoncteur à l'extrémité terminale des lignes .
- le passage direct de la tension de transport d'énergie à celle de distribution sans échelon intermédiaire de répartition . Exemple : réseau 150 kV transformé directement à 15 kV .

c) Conditions Economiques .-

Le financement des équipements constitue toujours une charge lourde pour un pays jeune . D'où la nécessité de concevoir des solutions simples , au besoin perfectibles par la suite . Seules sont à craindre, du fait de cette simplicité, les interruptions de service plus fréquentes, mais cet inconvénient est parfois acceptable quand l'industrie consommatrice n'a pas atteint un développement qui la rende trop exigeante.

Parmi les économies qui peuvent être faites, on peut citer :

- l'utilisation d'un seul jeu de barres omnibus, en premier stade .
- l'emploi de disjoncteurs autonomes du genre à petit volume d'huile,
- la suppression des disjoncteurs dans les travées des transformateurs .
- l'emploi de sectionneurs à deux colonnes .
- l'utilisation de conducteurs en aluminium au lieu du cuivre, etc ...

Dans le même ordre d'idée, il est intéressant de concevoir des solutions techniques faisant appel aux possibilités locales de manière à réduire l'importance du montant d'achat en devises . Un exemple typique est celui de la technique des massifs supports en béton maintenant généralisé dans ces pays puisqu'elle supprime une importation de charpentes métalliques en favorisant par contre la main-d'oeuvre locale .

Certaines solutions modernes peuvent demeurer complètement inintéressantes dans un pays plus à même de fournir lui-même une partie des équipements traditionnels C'est le cas souvent des dispositions classiques à l'intérieur de bâtiment en dur, moins onéreuses pour l'acheteur que des solutions préfabriquées entièrement métalliques .

d) Eloignement entre le fournisseur du matériel et l'exploitant .-

La notion de distance a une incidence très importante sur la conception des équipements en raison du temps nécessaire au remplacement du matériel avarié ou à l'envoi de spécialistes . Il conviendra de choisir, de préférence, un matériel simple et robuste ayant déjà fait ses preuves . Même si cela conduit à des solutions plus coûteuses, le risque d'avarie devra être divisé , en multipliant le nombre de tranches comme, par exemple , dans les centrales hydrauliques à l'accès difficile .

Pour la même raison, il conviendra d'approvisionner un lot de pièces de rechange et d'entretien plus important que pour des équipements situés dans des régions industrialisées . Ces pièces de rechange devront être conservées dans des emballages " longue durée " .

e) Incidence des possibilités réduites du transport .-

Le fait d'être obligé d'embarquer le matériel sur un navire, de le décharger dans un port parfois démuni de moyens importants de manutention, de le transporter ensuite sur des routes non aménagées avec des engins de capacité limitée et sur des ponts risquant d'être insuffisants, oriente le projeteur vers des solutions où l'expédition du matériel peut être divisée par petits colis . Exemple : subdivision des transformateurs de puissance et adoption de trois unités monophasées au lieu d'une grosse unité triphasée .

4) PROBLEMES PARTICULIERS DANS LA MISE EN OEUVRE .-

a) Etudes et Engineering :

La conception générale des équipements H.T. à installer dans un pays jeune doit être dictée par un souci d'adaptation aux conditions locales . Ceci nécessite une connaissance approfondie du pays et de ses coutumes .

Les études d'exécution doivent être menées jusqu'aux plus petits détails non seulement afin d'être rendues plus claires et plus compréhensibles aux yeux des monteurs envoyés au loin et des futurs utilisateurs , mais encore afin de permettre un dénombrement exact du petit matériel à expédier, et d'éviter ainsi des oublis dont les conséquences néfastes sont décuplées par la distance .

Enfin, le matériel susceptible de perte, de casse ou de vol doit être prévu largement (isolateurs, cuivre, boulons, etc ...)

D'autre part, on ne saurait trop insister ici sur l'importance de l'internationalisation rapide d'un certain nombre de normes électriques qui pourraient être adoptées sans difficultés par l'ensemble des pays en voie de développement . Cette question est capitale et on ne peut qu'encourager les efforts pratiqués dans ce sens par la Commission Electrique Internationale (C.E.I.) et émettre le voeu de voir se généraliser les normes qu'elle édicte .

b) Difficultés rencontrées dans le transport .-

Le matériel électrique souvent fragile risque des entreposages prolongés dans de mauvaises conditions (voyage en mer, lenteurs en douanes, absence de magasins appropriés, etc ...) . En outre, les manipulations nombreuses par un personnel peu habitué à ce genre de matériel, ont conduit à revoir complètement la conception des emballages . Certains emballages d'isolateurs, par exemple, sont plus coûteux que leur contenu .

Dans les régions à l'accès vraiement difficile, ce qui est le cas de certaines lignes H.T., le transport par hélicoptère s'est trouvé être moins coûteux que celui qui aurait consisté à construire des voies d'accès .

c) Montage .-

Une première nécessité s'impose ; l'envoi sur place d'une main-d'oeuvre qualifiée faute, généralement, de pouvoir la recruter localement. Le choix des Ingénieurs et Chefs monteurs ainsi envoyés au loin devra être particulièrement sélectif et porter, non seulement , sur les capacités techniques des intéressés, mais aussi sur leurs qualités humaines en raison des relations qu'ils seront amenés à avoir avec des autochtones dont une partie sera placée sous leurs ordres .

La connaissance de la langue du pays est particulièrement recommandée .

Ne pas oublier de prendre un outillage robuste . Les châssis et carrosseries des véhicules de chantiers sont plus vite hors d'état que les moteurs .

Une règle importante, pour la bonne exécution d'un chantier : le personnel envoyé sur place doit pouvoir bénéficier de conditions de vie convenable, sous peine d'une baisse de rendement notable .

5) FORMATION DU PERSONNEL AUTOCHTONE . -

La formation d'une élite technique constitue l'aide économique la plus efficace qui puisse être faite aux pays en voie de développement .

Il faut donc éviter de livrer des équipements trop complexes sans s'être assurés d'une formation convenable du personnel local appelé à prendre en main leur exploitation . Les contrats de ventes de grands ensembles devront donc prévoir une clause de formation de personnel et de maintenance des installations après leur mise en service , sous la surveillance de Techniciens compétents .

Pour l'acheteur, la meilleure manière de former rapidement son personnel technique est de le faire participer effectivement aux travaux de montage et de règlage du matériel .

Cette formule doit être complétée par celle des stages d'Ingénieurs et Techniciens dans les fabriques des constructeurs, ainsi que dans les Centrales et Postes de transformation de réseaux électriques déjà évolués, leur donnant une idée anticipée de leur propre réseau .

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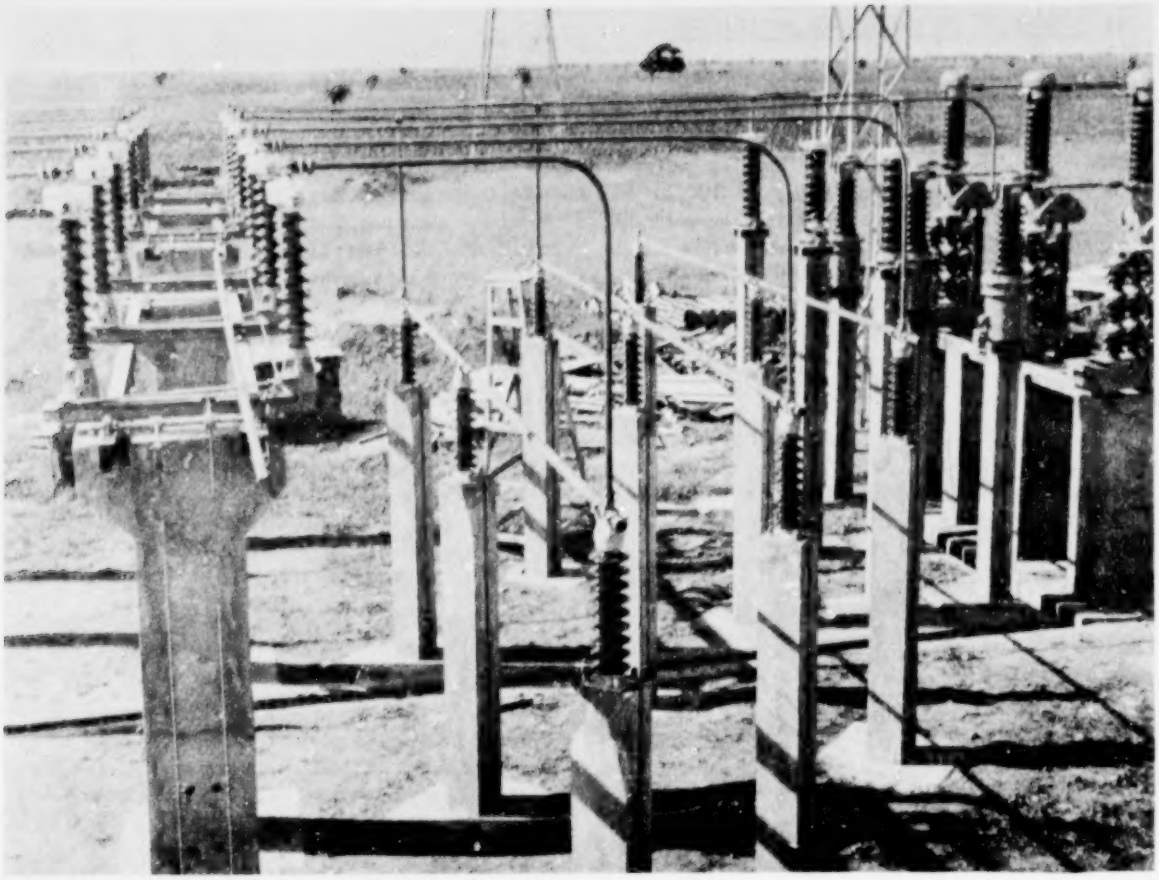

Exemple de Poste 60 kV économique avec : - sectionneurs simples à deux colonnes,
- jeu de barres omnibus unique, - massifs supports en maçonnerie .

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.3.1

France

SOME APPLICATIONS OF THE TECHNIQUE AND INSTALLATION OF HIGH VOLTAGE ELECTRICAL EQUIPMENT IN DEVELOPING COUNTRIES

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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SOME APPLICATIONS OF THE TECHNIQUE AND INSTALLATION OF HIGH VOLTAGE ELECTRICAL EQUIPMENT IN DEVELOPING COUNTRIES

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SUMMARY

1. INTRODUCTION

2. NATURE AND USES OF H.V. EQUIPMENT

   To transform and control energy. To protect equipment.

   Principal types of apparatus.

3. THE INFLUENCE OF LOCAL CONDITIONS ON THE DESIGN OF H.V. EQUIPMENT

   (a) Geographical and climatic conditions

   Temperature, winds, storms, earthquakes, nature of soil, dust, humidity, animal life.

   (b) Type of network

   Simplified pattern, radial network, therefore high voltage, low power.

   (c) Economic conditions

   Lack of funds at the start, therefore simple and extendible solutions.

   (d) Distance between the supplier of equipment and customer

   Considerable time taken up in transit, therefore reserve units needed.

   (e) Transport conditions

   Insufficient road facilities and small lorries, therefore light packages, division of power.

4. SPECIAL INSTALLATION PROBLEMS

   (a) Studies and Engineering

   Necessity for a detailed study in order to take all factors into account.

Urgent need for the internationalization of electrical standards.

(b) Transport difficulties

Careful packing because of fragility of electrical equipment.

(c) Installation

The provision of highly qualified specialized labour.

5. TRAINING OF NATIVE POPULATION

The training of technicians is the most effective economic aid that can be given to developing countries.

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Agenda Item: D.5

Brasil

INTEGRAL INDUSTRIALIZATION OF THE BABASSU PALM INCLUDING LOCAL GAS AND POWER PRODUCTION

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D.5

INTEGRAL INDUSTRIALIZATION OF THE BABASSU PALM INCLUDING LOCAL GAS AND POWER PRODUCTION

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I - INTRODUCTION:

1. Abundant national and foreign research and documentation concerning babassu vegetation and its energetic value dates from 1820 and 1922 respectively, and refers to the immense areas of Brazil covered by dense natural palm vegetation of Orbignya Speciosa, Attalea eleifera etc. in the tropical North, North-East and Interior from Amazonas to Maranhão, and as far south as Espírito Santo and Minas Gerais in the subtropical and moderate zones. This native vege - tation is, however, mostly concentrated in the States of Maranhão, Piauí and Goiás.
2. A comparison with the areas of most intense electrification in the Center-South and along the coast up to the State of Rio de Janeiro shows in a striking way that approximately the 2/3 of the national territory and the half of the Brazilian population that up to now do not enjoy the benefits of electrification are situated mostly in the areas occupied by babassu palm vegetation and by a poor, starving population needing regular jobs and better living standard.
3. About a thousand conventional babassu oil extracting industries, large and small, with subsidiary soap, candle and cosmetic manufacture employing 60,000 families of these palm weed areas,(1), are still completely dependent on primitive collecting and breaking of the hard nuts with an ax for a low income of some 50 US dollars per family a year, losing in this way some 94 percent of the nuts'weight unexploited, though it has already been shown experimentally that the other parts of the nut,besides the oil-containing kernels, are good raw material for economic production of numerous by-products.
4. The areas of largest babassu palm vegetation in the States of Maranhão, Piauí and northern Goiás only were estimated (2)(3) at some 100,000 km2 with some 80 (4) to 160 (5) productive palm trees per hectare, depending on whether additional pasture, rice or other cultures are planted among the palm trees or not. The dense native forest, e.g. in Maranhão, contain up to 3000 palms per hectare and have therefore to be cleared to assure rational production.
5. Selected and cleared palm vegetation is, according to several practical experiments, capable of large-scale industrialization.

This would include, besides the conventional oil extraction with subsidiary industries, the production of additional alimentary and industrial products, residual coke, steam, gas and electri energy sufficient for industrial consumption, as well as residential and rural electrification and eventual local siderurgical uses.

6. The development of such large-scale industrialization programs could elevate the relatively stagnant conventional comestible babassu oil production progressively from year to year, contributing with the numerous possible by-products of this integral babassu industrialization to the necessary diversification of Brazil's economy, to the elevation of living standards in under-developed areas, as well as to a solution of the world food problem.

II - MECHANIZATION AND RE-ORIENTATION OF MANUAL WORK

7. For the reasons mentioned in paragraph 1, complete mechanization, so far as possible, of palm wood clearing, nut harvesting, transport and drying methods (to a great part already practically experimented (6)), as well as automatic breaking of the nuts and separation of the parts and their further industrial refining (1)(6) are to be carried out on a larger, semi-industrial scale. It must be large enough for experimentation with destructive distillation of coke, gas and power, production, and steam and hot water production by heat recuperation, so as to obtain conclusive results for large-scale industrial installations able to produce an essential increase not only in the production of oil and new comestible and industrial by-products, but also in the agricultural and energetical uses and, in the eventual presence of local mineral deposits, also in siderurgical production.

8. The considerable amount of human manual work liberated by the mechanization of the nut breaking has to be reorientated by instruction and training to amplify wood clearing and nut harvesting, facilitated by easier access to the productive palm trees. To accelerate the palm wood clearing the young and still unproductive palm trees may, so far as possible, be torn down by small caterpillar tractors, provision being made for immediate carrying away of the eliminated small palm vegetation to avoid proliferation of insects.

9. This material should, from the beginning, serve for the production of comestible medulla ("palmito") for man and beast and the large quantities of palm leaves of these "unproductive" palms for local paper pulp when economically possible, and for paper manufacture.

10. The latter, where possible, could be an excellent solution for the problem of local manufacture of the necessary large quantities of sacks for the transport of the residual material from the kernels after oil extraction, which is a good commercial cake ("torta") for feeding animals or for production of fertilizing material.

11. Though the "mechanized" wood clearing mentioned in II (8) will require supplementary manual work for cutting and leading, it is obvious that the larger part of the manual labor freed from the traditional nut breaking by ax will be available for nut harvesting. Therefore a larger quantity of harvested nuts in comparison to the traditional method of harvesting and nut breaking by the same person may be expected, especially if easier access to adult productive palm trees is provided.

12. The mechanical separation of epicarp and mesocarp, and subsequent breaking of the hard woodlike endocarp and separation of the kernels, as well as of the comestible vitamin and starch-containing flower from

the mesocarp fibres, and of the tannin from the comestible flower has been tried out already on a semi-industrial scale, proving that the transportation of the whole nuts to the factory is economically justified only when other by-products also, and not only the comestible oil, are produced.

13. In this respect it is important to note that, according to analyses (2) of the total weight of the babassu nut, e.g., from Maranhão, there is: 15% epicarp, 20% mesocarp, 59% endocarp and only 6% oil-containing kernels, the only part up to now generally made use of. The interest in technological use also of the other components of the nut is consequently obvious.

14. It is suggested that the fibrous epicarp be experimentally used for pastebeard manufacture for local carton fabrication, for the transportation of manufactured material.

15. The mesocarp is of special interest because of its composition: 8,7% humidity, 0,7% oil, 66,2% starch, 0,9% tannin, 22,3% short fine fibres, 1,2% mineral matter. The whole nut contains more than 13,2% of starches against only 3,7% of oil conventionally utilized. In the technological process already experimentally used, 5% of the starch could be transformed, after tannin separation, into an alimentary fleur of original, agreeable taste ("Palmelate"), 10% remaining for forage and some 5% adherent to the fibrous parts, which could, eventually, be used for production of ethyl alcohol, butyl alcohol, acetone etc.

III. ENERGY PRODUCTION:

16. In paragraph II 13) we have seen that the hard, woodlike endocarp is some 59% of the whole weight of the babassu nut. With 6% for the kernels, 94% of the total weight of the nut remains for the shell as a whole, if not separated into its components by rather complicated technological processes. According to the more or less refined technology chosen, 50 to 94% of the total weight of the fruit will serve as fuel for gas, power and eventual residual coke, tar and hydrocarbon production. Therefore the babassu nut may be considered essentially as a fuel,(1) notwithstanding its importance as a source of high quality comestible and nutritive substances.

17. In spite of the evident economic limits, the best technological process for energy use of the babassu nut, with special regard to the peculiar Brazilian lack of good coal and present insufficient national petrolproduction, which covers only some 1/3 of consumption, seems to be the destructive distillation of the endocarp in industries of sufficient capacity, say some 400 to 4000 tons of whole babassu nuts per day, to guarantee an economic return on the complicated preliminary process of the separation of the shell into its components, as well to be able to use modern gas turbines of current reliable construction, which range from about 3,000 to 30,000 kW, corresponding to a daily production of about 60 to 600 thousand m3 of distillation gas of some 3,400 kcal/m3 and to an average efficiency of only 12,5% for turbines without heat recuperation from the exhaust combustion gases. The latter would, however, be indispensable in industries of this order of capacity, raising the overall efficiency to some 65 to 70% and yielding additional power production from the heat recuperation steam boilers, serving also diverse industrial processes.

18. The destructive distillation of 1 ton of the previously separated endocarp gives, on the average, about 351 kg of gas of some 3400 kcal/kg, 280 kg of an excellent coke of some 7800 kcal/kg, 50 kg of tar of 9000 kcal/kg, 3,8 kg of methyl-alcohol of 8500 kcal/kg as combustible components. So far as the residual coke is not used locally, e.g., in producer gas generators for vehicles, boats, locomotives etc., it may, as has already been tried out, be briquetted with its own tar so as to be economically transported to other places of consumption.

19. To avoid accumulation of the large quantities of ashes from the destructive distillation, it is suggested that they be pressed together with residual fibrous material into bricks for local civil engineering construction uses.

20. It is clear that it would be extremely hazardous to instal industries on the order of capacity referred to in paragraph III 17) without previous research on a smaller scale, particularly of the use of the "babassu-gas", still unknown as to its practical behavior, exception being made for some sporadic experimentation. The average composition of the gas from 25 experimental distillations at 900 to 1100° C during the relatively short time of some 3 hours, on the average, was:

CO_2	O_2	C_nH_m	CO	CH_4	H_2	N_2
20,8	1,0	2,8	22,6	18,3	16,8	17,7 % of total weight.

The high content, 22,6%, of CO may demand absolute tightness in operation for toxicity of this gas component, and also normal operation of the prime movers cannot be guaranteed without practical experimentation.

21. Furthermore it must be remembered that the bulk of the existing babassu oil industries are far below the capacity referred to in III 17). This facilitates the development of smaller industrial "micro-power stations" with excessing energy, to be successively interconnected by an electrical high tension transmission system.

22. Therefore it appears indispensable to instal an experimental, integral pilot babassu industry with a capacity of some 100 to 150 tons of whole babassu nuts per day, in order to be able to experiment with gas turbines of current construction, as well as modern reciprocating gas engines of various types, suitable also for smaller babassu industries, which cannot afford the expensive installation of reterts, accessories and gas-holders, as well as the complex technology of complete integral babassu processing, and must content themselves with the complete gasification of the whole nut shells in simple suction producer-gas generators. In order to be able to yield experimental results for the numerous smaller babassu industries, the gas-electric pilot power station should therefore be equipped, besides the destructive distillation plant, also with two or more producer-gas generators and reciprocating gas engines, suitable for relatively poor gas.

23. The transportation of the large quantities of nuts and industrial products would require for the trucks very much gasoline or Diesel oil, which is expensive, especially when transported to distant industrial sites. The use of the nut shells, of the separated endocarp or of the residual coke from dry distillation, in modern perfected gasogenes, mounted on the trucks, will assure independence

from expensive motor fuel.
24. Since reciprocating gas engines work with essentially higher temperatures than current gas turbines, the smaller babassu industries can be operated with reasonable efficiency by reciprocating gas engines with some 40 to 150 HP, using poor gas down to about 1500 kcal/Nm3. Using rich babassu distillation gas of some 3400 kcal/Nm3, modern piston gas engines up to 6000 HP, 600 r.p.m. could be tested in a pilot industry, as mentioned under III 22). The reciprocating gas engines reach gas temperatures up to about the double of some 720° C, admitted for gas turbines and thermal efficiencies up to 30 % and more, whereas gas turbines, e.g. of 2900 to 5800 kW show efficiencies of only some 15,4 to 18,8% respectively. This is the consequence of the limitation of gas admission temperatures for gas turbines, constructed today for petroleum derivates and natural gas of very high thermal values that cause vanadium corrosion at higher gas temperatures. Also construction material difficulties limit an essential raising of the gas temperatures. Therefore, at the actual stage of current gas turbine construction, gas turbines suitable for babassu distillation gas, with its rather modest thermal value are available only from 2900 kW upwards. Such gas turbines, which result in a considerable economy of space, could be also tried out in the gas-electric pilot power station. On the other hand, the piston gas engines are of more robust construction and will have less pre-compression extra-losses. For both types of these gas prime movers the over-all thermal efficiency can be raised by exhaust gas heat recuperation to some 70%.
25. The gas prime movers generally need pre-compression of the used gas, representing supplementary energy loss. The latter can be avoided or reduced by the use of modern producer-gas generators under pressure e.g. of the type "Lurgi", which permit not only the production of rich and light liquid hydrocarbones, but also the transportation of the produced gas economically to larger consumption centers at distances up to some 150 km. These possibilities begin approximately at a yearly production capacity of 4 to 14 million m3 of gas, (7) according to local conditions.
26. In fact we are very likely to find such favourable conditions in the areas of richest babassu vegetation. As an example we would mention, e.g., the partly installed experimental pilot station for integral industrialization in Quelru, some 105 km from São Luiz, Capital of the State Maranhão, as a large industrial and residential consumption center, and some 160 km in the opposite direction from Cedó, an industrial center with iron, ore and gypsum, anhydride and limestone deposits. This experimental pilot industry could be relatively easily completed by the necessary equipment for general experimentation of all the most convenient uses of babassu palm products, including all the alternatives of energy production, in order to get a solid basis for further development of perfected installation and operation of these industries.

IV - SIDERURGICAL APPLICATIONS:

27. The separation of metallic iron from its minerals requires the presence of a reducing agent in peculiar conditions and quantity. This agent is carbon in one of its commercially available forms, or carbon monoxide (CO).

28. Lack of good metallurgical and siderurgical coke requires a search for substitutes. The residual coke from destructive distillation of babassu nut shells, the endocarp, is a very pure coke with some (1) 4 to 5% of ash, and up to 0,033% of phosphorus and >0,033% of phosphorous and 0,066% of sulphur, the latter remaining always below the corresponding content of coke from the best imported coal, whereas the phosphorus content was found often quite variable according to local soil conditions.

29. The only disadvantages of coke from babassu shells for general siderurgical use are its relatively low mechanical resistance and generally small dimensions. It has, however, been found very suitable for electrical and other furnaces, where high purity and reactiveness and not mechanical resistance are necessary. So with the modern tendency to smaller furnaces without large mechanical stresses the applicability of babassu coke may increase. On the other hand physiochemical briquetting without melting of the agglutinating matter may also make possible wider application of this excellent reducing agent.

30. It has recently been observed that for reduction of ferrous minerals direct contact of the latter with solid carbon may be replaced without inconvenience by contact with CO-gas, produced either within or outside of the furnace. The latter method serves in a more economical and less complex way to form the "fusion beds" for present blast furnaces. A new Brazilian process under experimentation (8) produces, outside the furnace, abundant quantities of carbon monoxide to realize at sufficient temperatures the classical chemical procedure in complete analogy with that used in the reducing zones of conventional blast furnaces. The new Brazilian process provides also for enriching of the reducing gas by hydrogen, by means of recycling of the gas, which becomes synthetic with triple reducing properties.

31. In this way, when smaller local deposits of ferrous minerals, which do not justify transportation of the mineral to large centralized siderurgical plants, are available, small siderurgical plants may be combined with local integral babassu industrialization, by using its residual coke or the reducing gases produced, which if necessary, can be transported at higher pressure even to longer distances with smaller losses than the solid residual coke. The presence of small deposits of ferrous minerals in the areas of densest babassu vegetation justifies the hope of the possibility of such realizations in the near future.

V. RESEARCH, DEMONSTRATION AND TRAINING CENTER FOR BABASSU UTILIZATION:

32. To assure use on an industrial scale of tested processing, creation is suggested of a specialized "Research, Demonstration and Training Center for Babassu Utilization" (9) for applied research by testing and improving methods for palmwood clearing, harvesting and processing of babassu nuts and by-products, including destructive distillation and gasification of the shells and use of the gas produced, e.g., for power production and siderurgical processing.

33. This "Center" should be installed in a convenient babassu palm vegetation area, near or not too far from residential sites and local ferrous mineral deposits, assuring adequate immediate or future gas or power consumption to the gas and power plants to be installed in the "Center", to achieve, so far as possible, complete practical

semi-industrial results, applicable to future large industries of this type, including also the energetical and siderurgical research.
34. Successful methods and equipment would be demonstrated to all interested parties, especially to delegates and workers of the existing babassu oil industries, and suitable candidates would be trained in the tested, improved processing methods.
35. So far as possible, existing or available national equipment should be used. So far as necessary also, foreign equipment, experts and fellowships for suitable Brazilian technicians should be provided, and eventual foreign experts should be assisted by national counter - parts.

VI. CONCLUSION

36. With the purpose of stimulating exploitation of potential local gas, power and mineral reserves and to channelize them towards other industrial, rural and residential consumption centers with a broad view to future interconnection and interchange possibilities, bearing in mind the economic view point for Brazil as a whole and also the local endeavours reflected in various proposed laws, already published in the Official Journal of the National Congress, and to assure dynamic collaboration of all the other Authorities also competent for the exploitation of these very large vegetable oil and energy reserves of the world, the Concession Section of the Ministry of Mines and Energy suggests, in execution of Presidential and Ministerial recommendations, the creation of an Energy Working Group for Integral Babassu Industrialization in order to provide all the necessary steps for Governmental participation and supervision of the project by a centralized organization, assuring the active cooperation of all interested Ministries and Federal and Governmental and other interested Authorities, in order to achieve a modern and efficient exploitation of babassu as an important national fuel for gas, power (10) and mineral, as well as siderurgical, production.

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INTEGRAL INDUSTRIALIZATION OF THE BABASSU PALM INCLUDING LOCAL GAS AND POWER PRODUCTION

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NOTES

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INTEGRAL INDUSTRIALIZATION OF THE BABASSU PALM INCLUDING LOCAL GAS AND POWER PRODUCTION

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According to national and foreign research immense areas of Brazil are covered by dense, natural vegetation of the babassu palm (Orbignya Speciosa, Attalea oleifera, etc.), susceptible of integral industrialization in addition to the conventional extraction of the high quality edible oil from the kernels of the nut, and including production of other nutritive and industrial by-products, as well as gas, tar, coke and power, the latter in sufficient quantity not only for all the energetical demands of this industry but also for in - dustrial, residential and rural electrification.

Some hundreds of the existing conventional babassu oil extracting industries are still completely dependent on the manual breaking of the extremely hard nuts, executed exclusively by some 60,000 rural families living in miserable conditions and earning some 80 US dollars per year.

A complete reorientation from primitive nut breaking by ax to modern palm forest clearing, nut harvesting, transport and drying methods is suggested, leaving the nut breaking, as far as possible, to automatized machinery, so as to make possible a large increase of oil, by-product, and general industrial, energetical and rural production.

Systematic forest clearing assures from the beginning food production for men and cattle from the medulla of the smaller, un - productive palm trees cut down, as well as excellent fibres from their palm leaves for local pulp and paper manufacture.

Mechanical nut shelling and nut breaking has been already experimentally combined with the extraction of fine comestible starch and vitamin-containing flour from the mesocarp, after previous tannin separation. Also destructive distillation of the woody endocarp, after the foregoing kernel separation, has been tried, producing a gas of some 3400 kcal/Nm3 and semi-coke and tar of good quality for subsidiary industries, as well as briquettes from the coke-powder for better transportation of this extremely valuable fuel in Brazil.

In addition to the processes already tried, it is suggested that experiment also complete gasification, sparing the expensive reterts, accesseries and gas tanks be used for producer-gas generators, suitable for smaller industries and, alternatively, for larger plants, gasification under pressure this yielding high quality distillation products and making possible, simultaneously, transportation under pressure of high quality gas to greater distances.

Local power production will be assured for smaller plants by piston gas engines, for larger plants by gas turbines, both with heat recuperation boilers, producing steam for industrial processing and eventually additional power for residential, industrial and rural electrification.

The transportation of large quantities of nuts and industrial products would require for the trucks very much gasoline or Diesel oil, which are expensive, especially when transported to distant industrial sites. The use of the nut shells, of the separated endocarp or of the residual coke from dry distillation, in modern perfectionnated gasogenes, mounted on the trucks, will assure independence from traditional expensive motor fuel.

It is suggested that the locally produced gas or coke be used where possible for direct reduction processing of smaller ferreus mineral deposits in local siderurgical industries to be created in underdeveloped areas of the babassu forests.

It is suggested that the large quantities of easy melting ashes and a part of the residual fibreus material be pressed to briquets for local civil engineering construction use. Also the epicarp fibres must be tried out for pastebeard manufacture.

To assure proper technology for these parts of the processing, which have not yet been sufficiently tested, it is suggested that a specialized "Research, Demonstration and Training Center for Babassu Utilization" be created, comprising also an Experimental Gas-Electric Power Plant.

This Center should increase the efficiency of the existing babassu oil extracting industries, as well as future small and large integral babassu industries to be created eventually according to some of the various law projects already published in the Official Journal of the National Congress.

With the purpose of stimulating use of potential local excess gas and power availabilities and to channelize them also towards other industrial, residential and rural consumption, with a broad view to future interconnection possibilities, bearing in mind the economical viewpoint as a whole and in collaboration with all other Authorities also competent for the exploitation of the largest vegetable oil and energy reserves of the world, the Concession Section of the Ministry of Mines and Energy, carrying out Presidential and Ministerial recommendations, suggests the creation of an Energetical Working Group for Integral Babassu Industrialization for the purpose of preparing the necessary steps for an efficient integral industrialization of babassu, especially as a fuel for power and siderurgical production.

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France

ETUDE DES FONDATIONS A L'AIDE DE PENETROMETRES

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Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

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A l'heure actuelle il existe de nombreux procédés de reconnaissance des sols qui permettent d'établir l'avant-projet et le projet des fondations de bâtiments ou d'ouvrages d'art.

Ces procédés peuvent être classés en deux catégories principales :

a) Prélèvements d'échantillons intacts de sol et essais en laboratoire.

b) Essais in-situ.

La première catégorie est généralement couteuse et délicate. Elle nécessite un équipement parfois difficilement transportable.

Pour exécuter les sondages, l'eau est souvent un élément indispensable.

Dans les régions arides, ces sondages sont donc particulièrement onéreux.

Enfin, le fonctionnement d'un laboratoire de sol doit être assuré par des spécialistes qui sont encore actuellement relativement peu nombreux dans les pays en voie de développement.

Par contre, les essais in-situ sont économiques et surtout rapides. Le matériel correspondant est en outre d'un transport facilement réalisable.

Ils conviennent donc parfaitement aux pays neufs pour lesquels le réseau routier est en quelque sorte à l'état naissant.

Si les méthodes de reconnaissance in-situ sont nombreuses, l'interprétation des essais n'est pas toujours expliquée par les utilisateurs, de sorte que chacun interprête les résultats suivant sa propre formule.

Nous nous sommes efforcés d'établir une formule simple, accessible à tous futurs utilisateurs d'un des engins de mesure : le PENETROMETRE DYNAMIQUE. C'est sans doute l'appareil le plus

simple, le plus robuste, le plus économique et le mieux adapté aux vastes régions dépourvues de communications terrestres.

Il existe trois types principaux de pénétromètres dynamiques à cône :

- Pénétromètre dans lequel le fût et la pointe ont le même diamètre. Cet appareil mobilise à la fois le frottement latéral et la résistance de pointe, sans qu'il soit possible de dissocier ces deux termes. Pour cette raison, son application reste généralement limitée à la détermination de la force portante des pieux, ce qui d'ailleurs est discutable, la variation de la résistance en fonction du diamètre étant différente suivant qu'il s'agit de la pointe ou du fût.

- Pénétromètre comportant une tige centrale d'un diamètre sensiblement inférieur à celui de la pointe. Cet appareil ne mobilise en principe, que la résistance de pointe. Toutefois,dans le cas de sables purs à texture lâche, il peut arriver que le matériau se resserre autour du fût et exerce ainsi un léger frottement latéral. Heureusement, ce frottement parasite reste généralement faible comparativement au terme de pointe. Malgré cet inconvénient, le pénétromètre de ce type est le plus répandu.

- Pénétromètre comportant également une tige centrale de diamètre inférieur à la pointe, mais équipé d'un tube creux de diamètre identique à celui de la pointe. Ce tube, qui n'est pas lié à la pointe, permet d'empêcher les sols susjacents de se refermer et de frotter le long de la tige centrale. On élimine ainsi l'inconvénient signalé précédemment. Malgré ce perfectionnement les appareils de ce type sont peu utilisés car ils sont plus onéreux et d'un maniement plus difficile que les précédents.

Dans ce qui suit nous n'envisagerons que les pénétromètres dont le diamètre de la pointe est supérieur à celui de la tige centrale, c'est à dire, ceux qui permettent de mesurer la résistance de pointe seule. En règle générale, pour ces appareils, le diamètre de la pointe est compris entre 35 et 60 mm, et le cône forme un angle de 15 à 60°.

Parmi les différentes applications de ces pénétromètres, nous traiterons exclusivement de la détermination du taux de travail admissible sous une fondation à base élargie (fondation sur semelles) à partir des résultats de battage et cela pour différents types de sols.

Pour déterminer la résistance de rupture à la pointe d'un pénétromètre, à partir des résultats de battage, il existe différentes formules de valeurs inégale.

La plus connue et la plus généralement utilisée est la formule des Hollandais. Selon Monsieur CAQUOT, c'est cette formule qui s'écarte le moins de la réalité pourvu que l'on tienne compte du raccourcissement élastique du pieu ou du pénétromètre au cours du battage.

Rappelons que cette formule peut s'exprimer comme suit :

$$R = \frac{M^2 H}{S.\ e\ (P + P)}$$

R est la résistance unitaire

e est l'enfoncement unitaire du pieu (par coup de mouton)

M est le poids du mouton

H est la hauteur de chute du mouton

P est le poids du pieu

S est la section du pieu

Pour évaluer la force portante d'un pieu, au moyen de cette formule, on applique habituellement un coefficient de sécurité de 6. Ce coefficient de sécurité peut paraître élevé. En réalité il tient compte implicitement du fait que l'énergie produite par la chute du mouton n'est pas absorbée uniquement par l'enfoncement du pieu, mais également par les déformations élastiques de ce pieu.

Pour exprimer la véritable résistance de rupture du sol (résistance correspondant à un chargement statique) il convient donc d'introduire au dénominateur, en addition de l'enfoncement, un terme e_1 représentant le raccourcissement élastique du pieu. La formule des Hollandais ainsi corrigée devient :

$$R' = \frac{M^2 H}{S\ (e + e_1)(M + P)}$$

C'est cette formule corrigée que les Américains appellent "Formule de l'Engineering News Record". Dans la pratique, il est assez difficile d'évaluer directement le terme e_1.

Plusieurs auteurs ont établi des comparaisons entre les

forces portantes déduites, lors d'essais de pénétration, d'une part de la résistance du sol à l'enfoncement (pénétration statique) et d'autre part, de sa résistance au battage (pénétration dynamique). Leurs conclusions sont assez voisines.

Aux journées de Mécanique des Sols des 7, 8 et 9 Juillet 1952, Monsieur BUISSON a exposé les conclusions suivantes, basées sur un très grand nombre de cas :

" Si l'on appelle S la force portante statique totale (effort de pointe + frottement latéral) déduite des résultats de pénétration par pression, et D la force portante dynamique, calculée au moyen de la formule des Hollandais, sans coefficient de sécurité, (formule non corrigée) à partir des résultats de battage, on constate que tant que le refus au battage dépasse 2,5 mm le rapport S/D est voisin de 0,75, au moins dans des sols sableux, marneux ou calcaires. Ce rapport varie linéairement de 0 à 0,75 quand le refus varie entre 0 et 2,5 mm.

" ... pour quelques cas, le rapport S/D atteint ou dépasse 1, et c'est pour des sables grossiers, graviers ou sables entrecoupés de plaquettes.

" Pour d'autres essais, on a trouvé des rapports S/D de 0,5 et même de 0,3 : il s'agissait de sols vaseux ou argileux...".

Notre expérience personnelle confirme les conclusions de Monsieur BUISSON. Dans la plupart des cas, pour obtenir la résistance statique à la pointe du pénétromètre, il convient donc d'affecter la résistance dynamique (calculée au moyen de la formule des Hollandais sans coefficient de sécurité) d'un coefficient de réduction compris entre 0,5 et 0,75. Exceptionnellement, ce coefficient de réduction peut atteindre 0,3 (sol de très faible compacité ou à consistance molle) ou être voisin de 1 (sol grossier à frottement très élevé).

Nous ne prétendons pas que les essais de pénétration dynamique peuvent résoudre tous les problèmes de fondation.

Cependant, à défaut de procédés classiques de reconnaissance, les pénétromètres dynamiques peuvent fournir des renseignements très utiles pour l'établissement des avant-projets et projets de fondations.

En première approximation, nous pouvons donc fixer une règle simple pour déterminer le taux de travail admissible à partir d'un essai de pénétration dynamique : on prend le vingtième de la résistance de pointe calculée à partir de la formule des Hollandais.

Ce coefficient de minoration peut paraître excessif.

Il a été déterminé à partir des formules habituelles de Mécanique des Sols d'une part et des résultats d'expériences effectuées à ce jour, d'autre part.

Bien entendu, dans le cas où la nature du sol est mieux connue ce coefficient peut être plus faible, notamment par exemple pour une fondation à faible profondeur reposant sur un sol graveleux compact.

En tous cas, nous pensons que ce coefficient est toujours supérieur à 15.

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ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.14

France

SURVEYING FOUNDATIONS WITH THE AID OF PENETROMETERS

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and G. JACQUELINE,
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General Secretary of C.E.B.T.P.

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No. 1815

D.14

SURVEYING FOUNDATIONS WITH THE AID OF PENETROMETERS

By

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and G. JACQUELINE, Civil Engineer, General Secretary of C.E.B.T.P.

SUMMARY

A technique for exploring soil structure in common use in Europe to-day is based on the use of penetrometers.

These devices can easily be used in developing countries. Incidentally, they have been in use in tropical Africa for some time.

In this paper the authors describe the equipment and its use. The conclusion may be drawn that dynamic penetrometers can provide information which is of great help in making preliminary plans and plans for foundations.

Thus we can give a simple rule of thumb for determining from a dynamic penetration test the permissible working rate, i.e. to take the twentieth part of the peak resistance as determined from the Dutch formula.

This reduction factor may seem excessive.

It was determined from the usual formulas of soil mechanics and the results of recent experiments.

Of course, if the soil is a better known one this factor may be less, e.g. for a shallow foundation on a compact gravelly soil.

However, we think that this factor will in any case be greater than 15.

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Agenda Item: D.7

Federal Republic of Germany

CONTRIBUTION TO THE PROBLEM OF THE MANUFACTURE OF SPONGE IRON BY MEANS OF NATURAL GAS IN THE SHAFT FURNACE

By Dr. Roland WASMUHT,
Ing. habil.,
Essen

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CONTRIBUTION TO THE PROBLEM OF THE MANUFACTURE OF SPONGE IRON BY MEANS OF NATURAL GAS IN THE SHAFT FURNACE

by

Dr. Ing. habil. Roland Wasmuht, Essen.

The production of iron and steel directly from ore, i.e. without the use of the blast furnace, is an old metallurgical problem. Also in the course of the "Technical Age" there have been time and again experiments, since 1843, to produce iron and steel from ore direct. In 1942, R. Durrer[1] still mentioned 138 methods dealing with the direct production of iron and steel. Now about 30 processes are still concerned with this old problem, partly in laboratories, partly in pilot or in full-scale plants.[2] Of these 30 methods about 10 processes use gas as reducing agent. With part of those methods the gas is produced from coal, coke or oil. Some few processes have been dealing with the use of natural gas as reducing agent[3], and this is the topic of the following considerations.

Preparation of gas

In its original form natural gas, chiefly consisting of methane, is not quite suitable for reducing iron oxide. Therefore, in all cases it is necessary to reform the natural gas - prior to its use as reducing agent - to gas mixtures suitable for reduction purposes and rich in hydrogen. Reforming can be carried through with the aid of oxygen or steam. It takes the form of the following reaction:

$$CH_4 + 1/2\ O_2 = CO + 2\ H_2$$

$$CH_4 + H_2O = CO + 3\ H_2$$

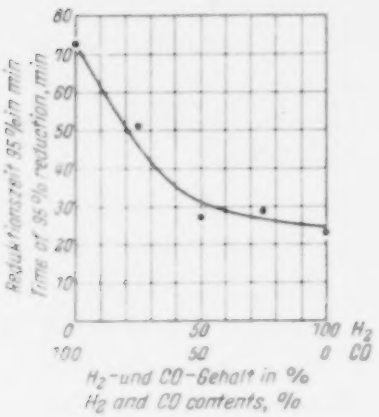
The reformed gas always retains a certain content of carbon dioxide and steam interfering with the reducing process. A good reducing gas for metallurgical purposes must meet the following requirements:

---

1) Metallurgie des Eisens - R.Durrer, Verlag Chemie GmbH, Berlin
2) Verfahren der direkten Reduktion von Eisenerzen, European Coal and Steel Community, Bibliography 1960
3) L.von Bogdandy, Stahl und Eisen 82 (1962), Page 869

Content of carbon dioxide and steam max. 2 %, methane max. 5 %, nitrogen max. 10 %. These requirements have to be complied with by a suitable control of the reforming process and, if necessary, by a following purification of the gas.

It is known that the reducing reaction is fundamentally different with carbon monoxide and hydrogen. Hydrogen-rich gases are utilized better at higher reduction temperatures. As to the reduction by carbon monoxide, however, lower reduction temperatures appear more favourable. Furthermore, it can be noted that hydrogen-rich gases reduce considerably quicker than carbon monoxide does (see Fig. 1).



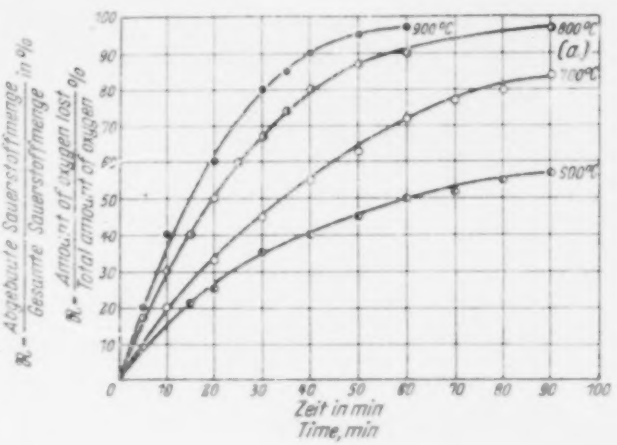
Time of reduction (degree of reduction: 95 %) as a function of hydrogen and carbon monoxide content of gas

Fig. 1

It is clearly to be seen that increasing temperatures result in a shorter time of reduction. However, an upper limit for the temperature is given by the softening of the ore. It lies at

The rate of reduction of pure hydrogen is three times as high as that of pure CO.

Finally the degree of reduction depends, to a great extent, on time of reduction and reduction temperature, as shown in Fig. 2 for the reduction with H_2.



Degree of reduction is a function of time and temperature. Isothermal reduction of iron(III)-oxide pellets (30 mm dia.) by hydrogen

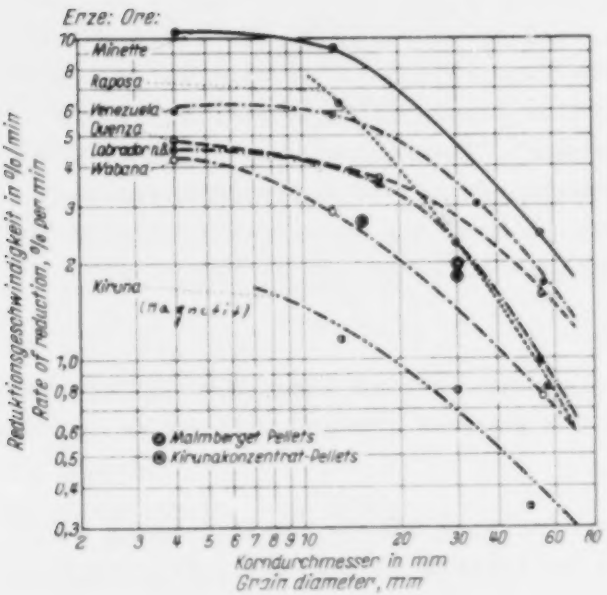
Fig. 2

about 1000 to 1100° C. An increase of the pressure will not result in any considerable acceleration of reduction so that it might hardly be necessary to revert to this means. This will substantially simplify the construction of the corresponding reduction furnaces.

The reduction process is based on the following formula:

$$Fe_2O_3 + 3\ H_2 = 2\ Fe + 3\ H_2O$$
$$+ 195\ kcal/kg\ Fe$$

$$Fe_2O_3 + 3\ CO = 2\ Fe + 3\ CO_2$$
$$- 69\ kcal/kg\ Fe$$



Relationship between lump size and rate of reduction of ores

Fig. 3

The rate of reduction is influenced, naturally, by the selected lump size of the ore input. The connection between lump size and rate of reduction is shown in Fig. 3.

Furthermore, it is to be noted that reduction of hematites is easier than reduction of magnetites. The max. lump size for the ore to be reduced lies between a grain diameter of 10 and 20 mm.

Reduction Process

Among the gas reducing processes the "fluidized-bed processes" occupy a special position.[1] According to these processes fine ores ground to the form of powder are reduced in

[1] J.Willems a. G.Quade, Stahleisen (1959), page 1058

a state of suspension in the gas. By this method optimum times of reduction are reached, it is true, but, on the other hand, its use in industrial scale is limited by the complicated mechanism derived from the chemical industry. For greater production units standing in competition with the "orthodox" manufacturing processes for iron and steel as usual, so far, chiefly such processes are coming into question using methods and types of furnaces approved in metallurgy as, for instance, rotary furnaces or shaft furnaces. The comments following below are limited to the description of the shaft-furnace process, the full-scale utilization of which in metallurgical works is approaching realization.

In practical metallurgy the shaft furnace represents the reaction aggregate par excellence. Blast furnace, cupola furnace, and lime-burning kiln are well-known examples for its application. The advantages of this furnace are to be seen in the automatical use of the counterflow principle, its easy operation (without motion of the furnace), its optimum heat balance and its optimum gas passage leading to an optimum output per unit of volume of reaction space. Therefore, it suggested itself to use the shaft furnace principle also for the method of direct reduction.

When reduction of the iron ore is carried through with natural gas in the shaft furnace, the process scheme[1] will be as follows (see Fig. 4).

One of the two gas reformer furnaces always is in working position whilst the other is in heating-up position. The ore is charged at the shaft furnace top, as usual, and travels - with progressive reduction - towards the lower part of the furnace. The hot reducing gas is fed into the shaft at the bottom and flows through the ore according to the counterflow principle. The reducing gas received at the top is partly used for heating the gas reformer furnaces and partly fed back (as circulating gas) into the gas reforming system.

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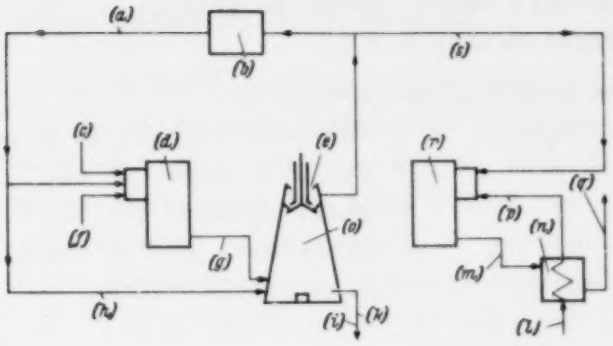
[1] L.von Bogdandy, Stahl und Eisen 82 (1962), Page 869

Fig. 4



Flow diagram of an industrial reduction plant with production of reducing gas from natural gas and oxygen.

(a) recovered top gas
(b) condensation of reaction water vapour to 35°C (dew-point) and compression
(c) methane (calorific value = 8580 kcal/Nm^3)
(d) reformer furnace I
(e) input: ore (Fe_2O_3)
(f) oxygen
(g) reducing gas (33 % CO, 67 % H_2; 1000°C)
(h) cooling gas
(i) sponge iron (97 % Fe, 2 % C; 300° C)
(k) to cooling drum
(l) blast (pressure 300 mm w.g.)
(m) waste gas (1000°C)
(n) recuperator
(o) reduction shaft
(p) hot blast (600°C)

When lump ore is used, the shape of the ore lump is maintained when it passes through the furnace and it is discharged as sponge iron of the same lump size. The same goes for the use of pellets which are very suitable for a reduction with natural gas in the shaft furnace. In this process the best results are reached with pellets having a diameter of 20 to 30 mm.

There are three different plants which are working at present, according to the shaft-furnace principle:

(q) waste gas (500°C)
(r) reformer furnace II
(s) top gas for combustion (300°C; calorific value = 2140 kcal/Nm3)

(1) The plant of M. Wiberg, Soederfors, Sweden,
largest production unit built: about 70 t/day,
shaft diameter/height ratio: 1 : 5;

composition of the reducing gas used:

H_2 %	CO %	CO_2 %	H_2O %	
21.1	74.4	3.2	1.2	The reducing gas is produced by means of coal gasification; the use of natural gas is taken into consideration.

(2) Plant of Finsider, Italy,
production unit: 70 t/day,
shaft diameter/height ratio: 1 : 5;

composition of the reducing gas used:

H_2 %	CO %	CO_2 %	H_2O %	
27	63	5	5	The reducing gas is produced from coal. It is intended to add methane.

(3) Purofer plant of Huettenwerk Oberhausen, Germany,
production unit: about 3 t/day,
shaft diameter/height ratio: 1 : 4;

composition of the reducing gas used:

H_2 %	CO %	CH_4 %	CO_2 %	
63.1	25.4	4.7	1.7	The reducing gas is produced by catalytically reforming natural gas.

The a/m Wiberg plants are satisfactorily working, in continuous service, for about 30 years. They produce sponge iron which is used as scrap in the charge of the steelworks.

The Finsider plant will be put into operation at the end of 1962. It serves as mere pilot plant for the member countries of the European Coal and Steel Community.

The Purofer plant in Oberhausen is manufacturing in continuous operation, for 2 years, about 3 t per day of sponge iron which

is then worked to iron powder for powder metallurgy. The relatively low production rate is due to the limited market for iron powder. A greater plant with a daily output of 50 t is under construction at present.

As to be seen from the above details, the reduction conditions are becoming more favourable with a higher H_2 portion in the reducing gas and with a higher reduction temperature. That means that, with the same output, the shaft volume becomes smaller with an increasing H_2 portion in the reducing gas. Thus, for instance, a furnace operated with H_2 would need only 1/3 of that shaft volume as required by a furnace using CO reduction as the reduction rate of H_2 is three times greater than that of CO (see Fig. 1). This is why, at present, the Purofer furnace requires the specifically smallest volume and the smallest height of shaft.

An increase of the output of the shaft furnaces working with natural gas, beyond the a/m rate, to production units of, for instance, 300 t per day of sponge iron per unit, obviously will not meet with any considerable difficulties as shaft furnaces with a discharge of solid material of these dimensions are known and are used in practice since long already (example: lime-burning kilns).

Deliberations concerning profitability

To judge the profitability of the gas reduction process as described above, it is interesting to ascertain, as comparison, the costs of pig iron arising when a) the traditional blast furnace process is used and b) ore reduction is carried through in the shaft furnace by means of natural gas and then synthetic pig iron is produced from the sponge iron with the aid of a suitable equipment for subsequent remelting. It seems to be advisable to select the pig iron manufacture as standard of comparison as pig iron is the usual raw material for the further iron and steel production in development countries with plentiful supplies of ore and, in most cases, a shortage of scrap

and which, therefore, is particularly suitable for comparison purposes.

The capital costs for a complete gas reduction plant, incl. remelting equipment, will show a minor difference only as compared to the costs for a blast furnace plant of the same size. Anyhow, they will be lower, due to the simpler and smaller shaft and to some other simplifications as compared to the blast-furnace process. But this reduction of the capital costs is neither decisive nor does it greatly influence the production costs. Likewise the fact that less manpower is needed will be relevant. Predominantly decisive and of first importance for all considerations in connection with the new process will be only and alone the fuel costs. In this respect the development countries disposing of natural gas have an essential advantage over the old industrial centers, e.g. in Europe. In South America, for instance, coke is very expensive as most of it has to be produced from imported coal. On the other hand, natural gas costs less than 0.5 c.(US$)/standard cu.meter. If the consumption of natural gas is charged with that price - the upper limit of the prices known to us - in the cost accounting, the fuel costs will amount to about $ 2.50 per ton of pig iron in such a combined sponge iron - pig iron plant. For a blast furnace located in South America the fuel costs would be about $ 16.50 per ton of pig iron. This disadvantage is decisive and could hadrdly be overtaken by the traditional blast furnace process - in spite of many improvements.

The a/m comments clearly show the great importance of the process, as described, for the future extension of iron industry in such development countries having gas and oil supplies at their disposal. For those countries, which often possess simultaneously cheaply mined ore reserves but, in most cases, are short of coking coal, the process of direct reduction of the indigenous iron ores by means of natural gas in the shaft furnace may become the decisive turning point for starting an own iron industry competitive on the world market.

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SUMMARY

Agenda Item: D.7

Federal Republic of Germany

CONTRIBUTION TO THE PROBLEM OF THE MANUFACTURE OF SPONGE IRON BY MEANS OF NATURAL GAS IN THE SHAFT FURNACE

By Ing. habil. Roland WASMUHT, Essen.

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CONTRIBUTION TO THE PROBLEM OF THE MANUFACTURE OF SPONGE IRON BY MEANS OF NATURAL GAS IN THE SHAFT FURNACE

By : Ing. habil. Roland WASMUHT, Essen.

S U M M A R Y

The direct reduction of iron ore by avoiding the blast furnace process is an old metallurgical problem which lately has gained in importance as now natural gas as a reduction agent has been established.

Natural gas, which consists mainly of methane, is in its original form not very suited for the reduction of iron ore. Before using it as a reduction agent it is, therefore, necessary to split it up into mixed gases rich in hydrogen. The splitting-up can be carried through by means of oxygen or steam. The resulting split gas contains mainly hydrogen and carbon oxide, the aim being to get as high a percentage of hydrogen as possible, because the reduction process with hydrogen is three times quicker than the one with carbon monoxide. The degree of reduction to be reached through natural gas depends, on the one hand on the time of reduction, and on the other hand on the temperature of reduction. Higher temperatures mean shorter reduction times. An increase of the pressure does not considerably speed up the reduction process.

The different processes of reduction by means of natural gas are thoroughly examined. The conclusion to be drawn is that in Iron and Steel Plants the shaft furnace as reducing vessel should be given preference. The working method according to the shaft furnace process is described in detail. The shaft furnace process has the advantage of the automatic application of the counterflow principle, the easy handling of the furnace, the optimum in heat economy and in gasing thoroughly. The product thus obtained is sponge iron which can be used as "synthetic scrap" in the

known steel production processes. Either lump iron ore up to 50 mm diameter or pellets with a diameter of 20 to 30 mm may be used for charging the shaft furnace.

Three different shaft furnace methods are described:

1 - Method according to M. Wiberg, Söderfors (Sweden)

2 - Method of Finsider (Italy)

3 - Purofer-Method of Huettenwerk Oberhausen AG (Germany)

When considering the economical side of the question it appears that direct reduction of iron ore in the shaft furnace by means of natural gas is particularly interesting for those countries which are rich in iron ore but do not have coking coal, only natural gas. For such countries the erection of a gas reduction plant could be more interesting from the economical point of view than the erection of a classical blast furnace plant.

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Agenda Item : D.7

Economic Commission for Europe

PROBLEMS ARISING IN THE ESTABLISHMENT AND DEVELOPMENT OF THE IRON AND STEEL INDUSTRY IN LESS DEVELOPED COUNTRIES

By The Steel, Engineering and Housing Division, Economic Commission for Europe

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D.7. Problems arising in the establishment and development of the iron and steel industry in less developed countries. by the Steel, Engineering and Housing Division, ECE.

1. Iron and steel products hold a key position in economic development since they constitute an important material component of agricultural and industrial equipment, power installations, transport facilities, construction and, at later stages, of many durable consumer goods. A close correlation exists, therefore, between indicators of economic growth (e.g. gross national product per capita, gross domestic fixed capital formation, industrial output, private consumption expenditure, etc.) and steel consumption per capita.[1] Furthermore, the product pattern of steel consumption undergoes certain changes concurrently with growth from early stages of development to mature industrial economies. In the initial phases of development relatively heavy and technically simple iron and steel products are required, such as iron castings and cast iron pipes, light forgings, concrete reinforcement rods, rails, merchant bars, heavy sections and galvanized sheets. With the development of light industries the demand for steel is expanding and the product pattern may change according to the nature of these industries, especially if metal using industries are concerned. In later stages of development, iron and steel products of a higher degree of finishing are needed. This is reflected in the increasing use of flat products (strip, plates and sheets) especially for consumers' durables, motor vehicles and certain types of machinery. Exceptions to this general sequence occur mainly in those countries where a particular activity, e.g. mining, crude oil production, meat-canning etc., requires specific steel products such as rails, sections, tubes or tinplate.

2. In countries which do not possess a steel industry, when economic development is started on a broad front, large quantities of steel products are required, which must be imported from industrialized countries. The scarcity of foreign exchange creates a strong incentive to establish an iron and steel industry in the country itself. This is sometimes favoured by the existence of sizeable iron ore reserves of sufficient quality, often already exploited and exported. Energy resources, whether in the form of coking coal, thermo or hydro-electricity, are in most cases scarce or insufficiently developed. A major problem also is the lack of skilled labour, a problem which is particularly important in the steel industry, since steel workers with sufficient technical skill can only be formed by long practical experience. It is for these reasons that in countries which do not have an iron and steel industry, the establishment of such an industry, which involves sizeable investments, is undertaken in carefully considered stages which proceed hand in hand with the increasing availability of skilled labour. This last problem is relatively easier to solve in those countries where iron and steel production has already existed for some time, and where economic development plans call for an expansion of output.

Problems of programming

3. The close relationship between steel consumption (or production) and economic development calls for the establishment of co-ordinated growth programmes for the iron and steel industry and for the other sectors of the economy. The size and the economic significance of an iron and steel industry requires a careful and detailed planning of the adjacent sectors, in particular of iron and manganese ore deposits, coking coal, energy resources, transport

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1) See "Long-term trends and problems of the European steel industry", ECE Geneva, 1959 (ST/ECE/STEEL/1), especially Chapters V and VI.

facilities, labour (not only for the steel industry itself, but also for the complementary branches) and of the market for the future output of iron and steel products. Although there is a vast potential demand for steel products in developing countries, it is important to evaluate the quantities, types and qualities of individual products required by the various steel consuming sectors.

4. In the establishment of a programme for the erection of an iron and steel-industry consideration is given to the following:

(a) A quantitive and qualitative survey is made of iron and steel-making raw materials (iron ore, maganese ore, limestone, coking coal, water, scrap, etc.). Since in many cases the type of equipment used in a specific plant depends on the quality of raw materials (e.g. high-phosphorous ores may lead to the use of oxygen-blown converters instead of open-hearth furnaces; in the absence of iron ore, a regular supply of scrap suggests the use of small electric furnaces; a lack of coking coal will result in the use of low-shaft furnaces, or other direct reduction installations, etc.), the suppliers of plant equipment will often carry out such surveys.

(b) The choice of the site of a plant is influenced by a number of factors which must be carefully evaluated. Calculations of assembly costs for raw materials and for shipments of finished products to the principal market area are required. The proximity of an industrial centre as a steel outlet, the availability of skilled labour, of port and other transport facilities, etc. will be given particular weight in such considerations.

(c) In addition to the considerations relating to the quality and type of raw materials, the choice of equipment and individual production processes depends on considerations of a purely technical and financial nature, since different types of equipment have different investment and operating costs, require varying degrees of skill of labour, or are suitable only for certain production programmes.[2] The final choice is also, sometimes, influenced by the availability of advantageous credit conditions.

(d) The planning of the production programme is dictated by the general plan for development, by the availability of technical know-how, and by cost considerations. Calculations are made of the total cost of a ton of a given type of finished product and compared with the price of a corresponding imported product. Often the cost of domestically produced steel compares, at least during the initial stages, unfavourably with similar imported products. This may be, however, offset by other considerations relating to foreign currency savings and general economic policy.

5. Often, especially in those countries where a domestic iron and steel production is established for the first time, the choice will be for relatively simple products in view of limitations in technical experience. This coincides generally, at early stages of development, with the requirements of the economy. More advanced products, (especially thin flats, cold-rolled sheets, steel tubes, etc.) are imported, and only later, as technical skill grows with experience will they be produced domestically.

6. In countries where iron ore is already mined for export, the establishment of an iron and steel industry may be approached differently: iron-making facilities are built often with technical and financial aid from the ore

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2). This problem has been dealt with in an ECE study Comparison of different steel-making processes (U.N. Publication Sale No.62.II.E/4, Geneva 1962) summarized in another paper submitted to the Conference.

importer and pig-iron is produced, partly for domestic use, and partly for export instead of iron ore. The advantage in transport cost is considerable (pig-iron has an Fe content of over 90 per cent against about 60 per cent in the case of high quality iron ore). Coke required for the production of pig-iron is imported by taking advantage of low return-freight rates of ore carriers. During the first years technical assistance in production is generally required to produce pig-iron of sufficient and constant quality in order to satisfy the users in industrialized countries.

7. Countries which aim at expanding an existing steel industry of some size, are greatly aided by the fact that experience exists already in programming and in steel-making techniques. Problems arising in output programming will be less considerable since the size and type of demand in the different sectors of the economy will be known through practical experience. Problems relating to the assessment of the effects which an expansion may have on raw materials, energy, the transport system and the labour force will remain approximately the same.

Problems of Financing

8. The price of iron and steel-making equipment and the cost of its installation are comparatively high, its actual level varying from country to country with the type of process used and the size of plant built. As a generally accepted rule-of-thumb, US$ 300 are taken as the cost of installing one ton of crude steel capacity in an integrated iron and steelworks; 3) consequently for setting up an integrated plant of 1 million tons crude steel capacity, US$ 300 million are required, and it is evident that this is beyond the credit capacity of many individual enterprises. Moreover, new iron and steel plants are not immediately profitable and offer, therefore, little incentive for foreign private capital investment. In those cases where suppliers of equipment advance loans or make direct investments in developing countries, these are generally guaranteed by the government or by inter-governmental agencies.

9. For the governments of the less developed countries, investment in a new iron and steel industry may represent a heavy drain on financial resources. As a result, new steel projects are often financed jointly by the government of the receiving country, international financial institutions, grants or loans from foreign governments, equipment producers and sometimes enterprises of the iron and steel industry establishing subsidiary plants abroad or serving as technical advisers. Only for the expansion of existing plants (for instance when a new blast-furnace is built or a steel-making furnace added to an existing shop), is one source of finance used in current practice.

10. Among the problems of financing iron and steel industries in developing countries two divergent factors are of considerable importance: on the one hand, it is economically advantageous to set up immediately sizeable units with a crude steel capacity of 1 million tons or more; on the other hand the lack or insufficiency of technical know-how and skilled labour as well as capital often calls for a development by successive stages, starting with one only or a combination of two successive of the three main phases of integrated

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3) See also "Long-term Trends and Problems of the European Steel Industry, E.C.E., Geneva, 1959, page 142, notes to table 94.

steel production, namely pig-iron making, crude-steel production or steel rolling and finishing. This approach may, in the long run, imply higher total costs and hence greater financial charges for the country concerned. On the other hand, it may avoid considerable initial losses and delays arising from shortcomings in technical know-how.

Labour problems

11. The training of skilled labour and technical personnel for the steel industry requires a relatively long period of time, since many operations in iron and steel production require, despite a generally well advanced state of automation, the interference of humans, based on judgement. Even in well established steel-producing countries, new installations will only reach full capacity and produce a satisfactory product after several months of experience. Moreover, many operations, especially in crude steel-making, cannot as yet be automated, and the quality of steel through certain additions to the steel-bath at the right moment may largely depend on the decisions of an experienced foreman. The shortage in developing countries of qualified workers directly attached to the production process is further aggravated by the need for highly qualified maintenance and repair personnel.

12. Prior or during the construction of an iron and steel plant, personnel at the foreman, technician and engineer level are often trained by the suppliers of equipment in the country of origin. It has also become common practice to establish technical colleges in order to provide some of the basic knowledge required for successful operation before production is started and during the lifetime of the plant.

13. An important contribution to training of skilled labour is made by engineers from industrialized countries who usually accompany the imported equipment, supervise its installation and remain for a certain "break-in-period" of the new plant.

14. The training of a sufficient number of workmen poses great difficulties, since a plant of 1 million tons of crude steel capacity usually employs between 10,000 and 15,000 workmen (as distinct from engineers, technicians and administrative personnel). Even if a relatively low level of skill is needed for the greater part of these workers, their formation requires a considerable schooling capacity. Moreover, the minimum technical skills required take sometimes years to develop in a given population group. Most of the workmen's training in new plants is undertaken by foremen and technicians.

15. In less-developed countries where there already exists a steel plant, the creation of a new plant is facilitated by the possibility of training well in advance a great part of the personnel required and of transferring or assigning temporarily to the new works experienced personnel from the existing plant. Internationally, great progress has also been made during the post-war years in providing help in training. There are many facilities provided under the bilateral aid programmes, and among the services offered by the international organisations, the manifold training activities sponsored by the International Labour Organization under the United Nations technical assistance programme and the Special Fund, and the group-fellowships programmes sponsored by the United Nations deserve special mention.

Concluding Remarks

16. The foregoing account touches only briefly upon some of the major problems arising in the establishment of iron and steel industries in developing countries. In addition to the usual difficulties encountered in the industrial development of these countries, the steel industry poses particular problems, in view of the size of the investments, the site and the skills of the labour force and the conditions relating to the prior or concurrent development of the needed raw materials and energy supply. The difficulties encountered are, however, by no means insurmountable, and experience shows that initial frictional losses decrease in importance, and that the time required for starting domestic iron and steel production is steadily shortening. International co-operation in this field has also been steadily expanding, facilitated by the fact that both the raw materials and the outlets of the iron and steel industry occupy an important position in international trade. Until the time comes when many of the less developed countries will have their own iron and steel industry, one area of further international co-operation may yield significant benefits, namely the pooling together of the resources of neighbouring countries in order to establish iron and steel plants with an economic size able to count on the markets of all participating countries. This avenue of co-operation is being given high priority in the United Nations and its regional economic commissions, especially the Economic Commission for Africa.

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ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item : D.7

Economic Commission for Europe

PROBLEMS ARISING IN THE ESTABLISHMENT AND DEVELOPMENT OF THE IRON AND STEEL INDUSTRY IN LESS DEVELOPED COUNTRIES

By The Steel, Engineering and Housing Division, E.C.E.

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

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Problems arising in the establishment and development of the iron and steel industry in less developed countries.
by the Steel, Engineering and Housing Division, ECE.

SUMMARY

1) Introduction

Iron and steel products hold a key position in economic development since they constitute an important material component of agricultural and industrial equipment, power installations, transport facilities, construction and, at later stages, of many durable consumer goods. A close correlation exists therefore between indicators of economic growth, (e.g. gross national product per capita, gross domestic fixed capital formation, industrial output, private consumption, expenditure etc.) and steel consumption per capita.

In countries which do not possess a steel industry, large quantities of steel products are required when economic development is started on a broad front. The scarcity of foreign exchange for their import creates a strong incentive to establish an iron and steel industry in the country itself. Although many developing countries possess sizeable iron ore reserves, energy resources and availability of skilled labour pose major problems. It is for these reasons that in developing countries the establishment of such an industry, which involves sizeable investments, is undertaken in carefully considered stages which proceed hand in hand with the increasing formation of skilled labour.

2) Problems of programming

The close relationship between steel consumption and production on the one hand and economic development on the other, calls for the establishment of co-ordinated growth programmes for the iron and steel industry and for the other sectors of the economy. In the establishment of a programme for the erection of an iron and steel industry, consideration is given to the following:

a) locational factors (availability of iron and steel-making raw materials, choice of site of a plant, availability of skilled labour and of transport facilities);

b) choice of equipment and production processes; these are closely related to the quality and type of raw materials available and depend also on considerations of a purely technical and financial nature;

c) planning of the production programme; this depends on the general plan for the development of a country, on the availability of technical know-how and cost considerations.

3) Problems of financing

The price of iron and steel making equipment and the cost of its installation are comparatively high and often this is beyond the financial capacity of individual countries. As a result, new steel projects are often financed jointly by the government of a developing country, international financial institutions and by loans from foreign governments, equipment producers and sometimes enterprises of the iron and steel industry establishing subsidiary plants abroad.

4) Labour Problems

The training of skilled labour and technical personnel for the steel industry requires in general, a relatively long period of time. The shortage in developing countries of qualified workers directly attached to production is further aggravated by the need for highly qualified maintenance and repair personnel. Internationally, great progress has been made during the post war years in providing help in training. There are many facilities provided under the bilateral aid programmes and among the services offered by the international organisations, the manifold training activities sponsored by the International Labour Organisation under the United Nations technical assistance programme and Special Fund, and the group-fellowship programmes sponsored by the United Nations deserve special mention.

5) Conclusions

The paper touches only briefly upon some of the major problems arising in the establishment of iron and steel industries in developing countries. In addition to the usual difficulties encountered in the industrial development of these countries, the steel industry poses particular problems in view of the size of investment, the size and the skill of the labour force and the conditions relating to the prior or concurrent development of the needed raw materials and energy supply. The difficulties encountered are by no means insurmountable, and experience show that initial frictional losses decrease in importance and time required for starting domestic iron and steel production is steadily shortening.

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